JAPANESE [JP,11-354064,A]

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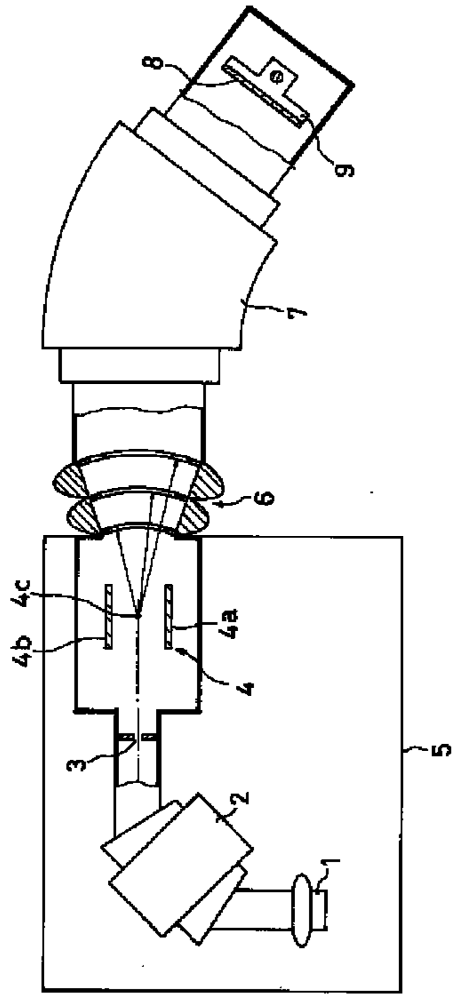
DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]The degree of incidence angle to a substrate has been kept the chemical element which ionized this invention mainly in the manufacturing process of an integrated circuit, and carried out mass separation constant. It is related with the ion implantation equipment for devoting oneself to the substrate of a major

Drawing selection
Representative drawi



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diameter with the energy of about hundreds of keV from the number keV, maintaining 1% or less of homogeneity as distribution of the injection rate on a substrates face.

[0002]

[Description of the Prior Art]The device of composition of having been conventionally shown in drawing 7 as average current type ion implantation equipment is known. The 1st sector electromagnet b for ion source a to which the potential which this device became independent of, respectively is given, and mass separation is arranged, Ahead [of this 1st sector electromagnet b] the 1st electrostatic deflection device f that consists of the mass separation slit d, the cylindrical acceleration tube e, and a multiple electrode in accordance with the 1st optic axis c, and the 2nd electrostatic deflection device g that similarly consists of multiple electrodes are arranged, and, ahead [the], it has the composition by which the fixed substrate h has been arranged further.

[0003]This ion implantation equipment from ion source a for example, the ion pulled out with the energy of 30keV, After only the ion of predetermined mass sorts out by passing the 1st sector electromagnet b and the mass separation slit d, it flies in accordance with the 1st optic axis c, and accelerates or slows down from the number keV to the predetermined energy of hundreds keV(s) with the acceleration tube e. The ion which reached predetermined energy is deflected in a certain field which includes the 1st optic axis c by the 1st electrostatic deflection device f, and enters into the substrate h which was deflected in the direction almost contrary to the 1st electrostatic

deflection device f, and was fixed to it by the 2nd electrostatic deflection device g. By changing the deflection angle and deflection surface in the 1st electrostatic deflection device f and the 2nd electrostatic deflection device g, and scanning them in two dimensions, ion can be poured in with sufficient homogeneity, keeping constant the angle injected into the substrate h.

[0004]It may become impossible for the ion under flight to serve as neutrality electrically, and to control the part by the collision with residual gas, etc. electromagnetically in ion implantation equipment, generally. The 2nd electrostatic deflection device g and the substrate h are installed on the basis of the 2nd optic axis i shifted about 7 times as opposed to the 1st optic axis c in order to remove such a neutral particle.

[0005]What front composition considered as the composition shown in drawing 8 from the acceleration tube as other examples of conventional average current type ion implantation equipment is known. In the figure, the ion which mass separation was carried out and became the predetermined energy which passed the acceleration tube which is not illustrated is scanned in a fixed field in the electromagnet j for a scan. The 2nd sector electromagnet k is formed so that the deflection surface may be in agreement with the scan layer in the electromagnet j for a scan ahead of this electromagnet j for a scan, and the substrate h is installed on the platen l mechanically driven in the direction which intersects perpendicularly with the scan layer. Although a sector electromagnet generally performs a convex lens operation to an ion beam, when it coincides the focus of the

entrance side of the 2nd sector electromagnet k with the deflection center in the electromagnet j for a scan, the degree of incidence angle of the ion irradiated by the substrate h is concerned with the scanning angle in the electromagnet j for a scan, and becomes there is nothing and fixed. By using together the scan of the ion beam in the electromagnet j for a scan, and the instrumental scan of the platen l, ion can be poured in with sufficient homogeneity, keeping constant the angle injected into the substrate h.

[0006]As an example of further others of conventional average current type ion implantation equipment, the thing of composition of being shown in drawing 9 is known. In this device, the electrostatic deflection device m which consists of an electrode of a couple is formed ahead [of the mass separation slit d], Ahead [of this electrostatic deflection device m] the convergence electromagnet n which gave the strong convex lens operation to the ion beam is formed, and, ahead [the], the rectangle acceleration tube o whose longitudinal direction corresponds with the scan layer in the electrostatic deflection device m is formed. The substrate h is installed on the platen l mechanically driven in the direction which intersects perpendicularly with the scan layer in the electrostatic deflection device m. By coinciding the entrance-side focus of this convergence electromagnet n with the deflection center in the electrostatic deflection device m, the angle of the beam which enters into the rectangle acceleration tube o is not concerned with a scanning angle, but becomes fixed. Although an acceleration tube generally has a lens action to an ion beam, in the case of a rectangular

acceleration tube, the lens action about the longitudinal direction is small. Therefore, by coinciding the longitudinal direction of the rectangle acceleration tube o with the deflection surface in the electrostatic deflection device m, the degree of incidence angle of the ion irradiated by the substrate h is concerned with the scanning angle in the electrostatic deflection device m, and becomes there is nothing and fixed. By using together the scan of the ion beam in the electrostatic deflection device m, and the instrumental scan of the platen l, ion can be poured in with sufficient homogeneity, keeping constant the angle injected into the substrate h.
[0007]
[Problem(s) to be Solved by the Invention]The size of the substrate with which it is used for manufacture while, as for an integrated circuit, a degree of location becomes high in connection with improvement in the speed of a device every year is large 200 or 300 mm from 150 mm in diameter every year.
[0008]In the case of the ion implantation equipment used by manufacture of an integrated circuit, electrification conversion according [the ion under flight] to the collision with residual gas, etc. becomes a cause, What is called energy contamination poured in with different energy from predetermined energy, the abnormalities in distribution into which it inclines toward spatially on a substrate and a chemical element is poured, etc. have been a big problem which worsens productivity. According to the degree of location of a semiconductor device becoming high, the demand which reduces energy contamination and the

abnormalities in distribution is strong.

[0009]Enlargement of board size makes improvement in productivity the key objective, and although board size becomes large, the request of shortening the processing time per substrate consists. In the case of ion implantation equipment, the current of an ion beam also needs to increase in connection with board size being enlarged, but the quantity of heat supplied to a substrate by the increase increases, and since degasifying becomes an increasing tendency, energy contamination and the abnormalities in distribution are posing an increasingly serious problem.

[0010]On the other hand, it is not desirable from the layout of a volume-production facility for a device to become large-sized since ion implantation equipment is comparatively large-sized also in a semiconductor manufacturing device. Since an end station cannot but become large inevitably in connection with board size becoming large-sized, this request cannot be met if the field where an ion beam flies is not made as small as possible.

[0011]In the conventional ion implantation equipment of drawing 7, electrification conversion of the ion under passage leads the 2nd electrostatic deflection device g to unusual distribution with the substrate h. On the other hand, since [almost equivalent to the size of the substrate h or] it is larger than it, the inside diameter of the 2nd electrostatic deflection device g tends to diffuse degasifying from a substrate inside the 2nd electrostatic deflection device g immediately, and has a tendency which the pressure in this field tends to increase. Therefore, degasifying

increases from a substrate with the increase in beam current, and there is inconvenience which is easy to cause the abnormalities in distribution.

[0012]In the conventional ion implantation equipment shown by drawing 8, in order not to be concerned with the scanning angle in the scanning electromagnet j but to inject ion into the substrate h at a fixed angle, the scanning electromagnet j needs to be set to the entrance-side focus of the 2nd sector electromagnet k. The energy of the ion which passes the 2nd sector electromagnet k is equal to infused energy. If the example of specification required of the 2nd sector electromagnet k supposing pouring in the phosphorus (P) which is typical pouring ion by 300keV is given, magnetic flux density will serve as 0.3 STELLAs, a deflecting angle will turn into 45 degrees, and the distance from the entrance of 1 meter and an electromagnet to an entrance-side focus of an orbital radius will be 1 meter. As a result, the distance required even for the substrate h from the scanning electromagnet j can also be 3 meters.

[0013]The ion implantation equipment of composition of being shown furthermore in drawing 9 is also publicly known, and in this device, since the energy of the ion which passes the convergence electromagnet n is equal to the energy at the time of being pulled out from an ion source, generally it is comparatively as low as about 30 keV. Therefore, the convergence electromagnet n is comparatively small, it ends, and the problem said that the distance from the electromagnet j for a scan to the 2nd sector electromagnet k becomes long like the conventional device of

drawing 8 does not arise. However, for the structure which is easy to diffuse degasifying from the substrate h inside the rectangle acceleration tube o comparatively easily in the device of drawing 9, The ion accelerated or slowed down in the rectangle acceleration tube o causes electrification conversion by the collision with gas, is injected into a substrate with different energy from predetermined energy, and tends to cause energy contamination.

[0014]This invention solves the above-mentioned problem, even if board size becomes large-sized, a device does not enlarge it, but an object of this invention is to provide ion implantation equipment with few energy contamination and the abnormalities in distribution.

[0015]

[Means for Solving the Problem]An electromagnetic scan of an ion beam within a scan layer which accelerates or slows down ion which carried out mass separation to predetermined energy in this invention, and includes a reference axis of a beam, In ion implantation equipment which combined an instrumental scan to which a substrate by which an ion implantation is carried out along a straight line which intersects perpendicularly with this scan layer is moved, The 1st sector electromagnet and mass separation slit for carrying out mass separation to a course of this ion beam are provided, An electrostatic deflection device for scanning a beam ahead of this mass separation slit and an acceleration tube provided with two or more circular electrodes are formed one by one, The above-mentioned purpose was attained by installing the 2nd sector

electromagnet whose deflection surface furthermore corresponds with a deflection surface of this electrostatic deflection device ahead of this acceleration tube, and coinciding a center of curvature of a circular electrode of this acceleration tube, and an entrance-side focus of this 2nd sector electromagnet with a deflection center of this electrostatic deflection device, respectively. It is also possible to provide an electromagnet for a scan instead of this electrostatic deflection device, and it is preferred to provide the 3rd sector electromagnet whose deflection surface corresponds with the above-mentioned scan layer between this mass separation slit, this electrostatic deflection device, or an electromagnet for a scan. The 3rd sector electromagnet whose deflection surface corresponds with the above-mentioned scan layer instead of this electrostatic deflection device is provided, A portion in which this 3rd sector electromagnet is provided among vacuum chambers which the above-mentioned ion beam passes may be made to become independent electrically, and an ion beam may be scanned within this scan layer by modulating potential of ion which passes this 3rd sector electromagnet further. By coinciding a deflection surface of this 3rd sector electromagnet with a deflection surface of the 1st sector electromagnet of the above for performing mass separation, and making direction of a magnetic field in this 3rd sector electromagnet into direction of a magnetic field in this 1st sector electromagnet, and reverse, It is preferred to use a reference axis of a beam in this portion as S character or Z shape.

[0016]
[Embodiment of the Invention]When an embodiment of the invention is described based on a drawing, in drawing 1, the numerals 1 show the ion source which emits ion to beam shape, The 1st sector electromagnet 2 and mass separation slit 3 for carrying out mass separation only of the ion specific out of an ion beam ahead of this ion source 1 are provided, and the electrostatic deflection device 4 which consists of the electrodes 4a and 4b of the couple for scanning an ion beam in a field fixed ahead of this slit 3 is formed. These are placed inside the high voltage terminal 5 in the potential which became independent of a grand level electrically. Ahead [of this electrostatic deflection device 4] it is formed by the acceleration tube 6 with which the center of curvature consists of a circular electrode which is in agreement with the deflection center 4c in the electrostatic deflection device 4, and ahead [the], The 2nd sector electromagnet 7 was formed in the position in which the entrance-side focus corresponds with the deflection center 4c, the platen 9 which can be mechanically driven along a vertical straight line, the straight line, i.e., the space, which intersect perpendicularly ahead [the] further at the scan layer in this electrostatic deflection device 4, was formed, and the substrate 8 by which an ion implantation should be carried out was fixed to this platen 9. The electromagnet for a scan (not shown) may be used instead of the electrostatic deflection device 4.
[0017]As shown in drawing 2, this acceleration tube 6 comprised the circular electrodes 6a, 6b, and 6c of three sheets which consist of a part of concentric circle pipe, the 1st electrode

6a is the high voltage terminal 5 and same electric potential, and the last electrode 6c is in a grand level electrically. The potential of the middle electrode 6b may consist of two or more sheets if needed, although it is arbitrary and the number of the middle electrodes 6b is one in the figure further. However, all the electrodes require that the center of curvature in 4 d of deflection surfaces of the electrostatic deflection device 4 which is a scanner should have agreed in the deflection center 4c in this deflecting system 4.

[0018]The electric field made from this example by the circular electrodes 6a, 6b, and 6c which consist of a part of concentric circle pipe is concerned with the potential formed there, there is and it does not have an ingredient of the hoop direction (namely, the direction of an angle) of a concentric circle. [no] Therefore, the charged particle scanned within the scan layer 4d by the electrostatic deflection device 4 is not concerned with acceleration or a slowdown with the acceleration tube 6, but the orbit within the scan layer 4d continues a straight-line motion without changing. Since the entrance-side focus of the 2nd sector electromagnet 7 is in agreement with the deflection center 4c of this deflecting system 4, the ion which passes the 2nd sector electromagnet 7 and enters into the substrate 8 is not concerned with acceleration or a slowdown with the scanning angle and the acceleration tube 6 in this deflecting system 4, but becomes a fixed angle to the substrate 8. Ion can be injected into the substrate 8 with sufficient homogeneity, keeping the angle to the substrate 8 constant, when the platen 9 scans the substrate 8

mechanically along the straight line which intersects perpendicularly with 4 d of scan layers simultaneously with the scan of this electromagnetic beam.

[0019]Generally the abnormalities in distribution are caused by degasifying produced when an ion beam is irradiated by the substrate 8. If this invention makes it one technical problem to cancel this abnormality in distribution and the influence about this is explained, it will be as follows. When the size of the substrate 8 is 300 mm in diameter, the width which a beam scans is required about about 40 cm. In this case, although the effective area product of the 2nd electrostatic deflection device g in the conventional device shown in drawing 7 becomes beyond a 1170-cm^2 grade, In the example of drawing 1 of this invention, since 10 cm or less of the height of the opening of the 2nd sector electromagnet 7 is enough, the effective area product serves as a 400-cm^2 grade, and becomes about [of a conventional example] 1/3. Therefore, the grade which an ion beam collides with residual gas in the inside of the 2nd sector electromagnet 7, causes electrification conversion, shifts from a predetermined orbit, and causes the abnormalities in distribution will be less than [1/several] compared with the case of the 2nd conventional electrostatic deflection device g.

[0020]If this invention also makes it the technical problem to cancel the energy contamination caused by the electrification conversion produced in the case of acceleration or a slowdown and the influence about energy contamination is explained, it will be as follows. Generally the orbital radius R of the charged particle in the inside of a sector electromagnet is given by

$R=(2M\ phi/e)^{1/2}/B$. As for the mass of a charged particle, and phi, an electric charge and B of electrostatic potential and e are [M] the magnetic flux densities of a sector electromagnet here. When electrification conversion is caused in the middle of acceleration or a slowdown, the electric charge e of a charged particle and electrostatic potential phi change a lot. Therefore, the orbit in the 2nd sector electromagnet 7 of these particles differs from a predetermined thing greatly, and it is predicted that the most does not reach the substrate 8. Since the 2nd sector electromagnet 7 exists between the substrate 8 and the acceleration tube 6, the grade which degasifying emitted from the substrate 8 diffuses even inside the acceleration tube 6 becomes small overwhelmingly compared with the conventional example of drawing 9. Therefore, according to this invention, energy contamination becomes less than the conventional thing overwhelmingly.
[0021]In the device of this invention, since the acceleration tube 6 is incorporated between the electrostatic deflection device 4 and the 2nd sector electromagnet 7, it is not necessary to place an acceleration tube like a device before between an electrostatic deflection device and an ion source or between a convergence electromagnet and a substrate, and a distance in the meantime is utilized effectively. Although it is necessary to scan the ion beam accelerated by even the energy injected into a substrate, and to carry out the abundance grade deviation of the ion beam of the high energy of about 300 keV at the best in the device of drawing 8, Since the energy of an ion beam deviates in about 30 keV and

the comparatively small state in the device of this invention, the size below half of the electromagnet j for the 2nd scan of the device of drawing 8 may be sufficient as the size of the electrostatic deflection device 4. Generally, the length of an acceleration tube is 0.5 m thru/or about 1.0m, and the length of the deflecting system which deflects the ion beam of about 300 keV is also required for about 0.5m. In the case of this invention, the length of a beam system of a device is short realizable about at least 1 m compared with the thing of drawing 8.

[0022]The devices shown in drawing 3 are other examples of this invention, and the composition which formed the 3rd sector electromagnet 10 between the mass separation slit 3 and the electrostatic deflection device 4 in this is different from the thing of drawing 1. It is as follows when the meaning on the ion optics of this 3rd sector electromagnet 10 is theoretically explained based on drawing 4 a and drawing 4 b. In ion implantation equipment, it is necessary to scan a beam on a substrate, keeping constant the degree of incidence angle to a substrate, as already stated. In order to be able to come, simultaneously for ion to be irradiated with sufficient homogeneity by the substrate, it is desirable for the size of the beam spot on a substrate to be sufficiently small as compared with the size of a substrate. In order to satisfy these two requirements, it is required that the deflection center of the deflecting system which scans a mass separation slit and a beam, the 2nd sector electromagnet as a convex lens, and substrate ** should have a relation like

drawing 4 a. That is, it is required for image A' by convex lens C of the mass separation slit A to carry out image formation on the substrate D, and for the deflection center B to be in agreement with the entrance-side focus E of convex lens C. Unless it is separated from the mass separation slit A and the deflection center B of a certain amount of distance, the above-mentioned conditions are unrealizable so that clearly from this principle drawing 4 a. On the other hand, as shown in drawing 4 b, this distance can be substantially shortened by inserting 2nd convex lens F between the mass separation slit A and the deflection center B. By adopting the 3rd sector electromagnet 10 still like drawing 3 as a lens to an ion beam, As shown in drawing 3, the reference axis of the beam in the inside of the high voltage terminal 5 serves as U shape, and it not only can shorten the distance of the mass separation slit 3 and the deflecting system 4, but it can shorten the overall length of a device substantially.

[0023]The device shown in drawing 5 is an example of further others of this invention, and the composition from which the vacuum chamber portion surrounded by the 3rd sector electromagnet 10 in this was electrically made independent, and the electrostatic deflection device 4 was removed is different from the thing of drawing 3. The chamber portion 13 which has formed said 3rd sector electromagnet 10 was made to become independent electrically with the insulating insulator 12 and the insulating insulator 14 in this example among the vacuum chambers which an ion beam passes. By modulating the

potential of this chamber portion 13 to the high voltage terminal 5, the deflection angle in the 3rd sector electromagnet 10 can be changed, and, thereby, a beam can be scanned. In this example, since the deflecting system 4 formed ahead of the sector electromagnet 10 in the example of drawing 3 is omissible, the overall length of a device can be further shortened rather than the example of drawing 3.

[0024]Drawing 6 showed the example of further others of this invention, and made the direction of a beam deflection in the 1st sector electromagnet 2 it of the 3rd sector electromagnet 10, and reverse in this. Although the ion source 1 needs a maintenance most frequently in ion implantation equipment and it is necessary to perform attachment and detachment of the ion source 1 from the space between the high voltage terminal 5 and the end station which is not illustrated in the example of drawing 3, In the example of this drawing 6, attachment and detachment of the ion source 1 can be performed from the outside of a device. Therefore, in this case, only an ion source can be made to be able to project, and a device can be constituted, without equipping on a large scale, and a maintenance becomes easy.

[0025]

[Effect of the Invention]When based on this invention as mentioned above, for the ion beam course of ion-implantation-equipment ** which combined the electromagnetic scan of an ion beam, and the instrumental scan of the substrate. The center of curvature of the electrode with this

circular acceleration tube which installs the 1st sector electromagnet, a mass separation slit, an electrostatic deflection device, the acceleration tube that consists of the shape of two or more circle, and the 2nd sector electromagnet whose deflection surface corresponds with the deflection surface of this electrostatic deflection device, Since the entrance-side focus of this 2nd sector electromagnet was coincided with the deflection center of this electrostatic deflection device, respectively, even if board size is large-sized, the abnormalities in distribution of ion and an ion implantation with little energy contamination can be performed to a substrate, a device can be constituted small and there are effects -- the easy ion implantation equipment of a maintenance is obtained.

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